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In the six month period between June 1996 and November 1996 we have looked into two problems related to data fusion from multiple sensors. The first deals with the distributed constant false alarm rate radar target detection and the other examines a rank based test for M-ary detection problem.

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Semiannual Report on the Contract- N00014-94-1-0736

Title   **Distributed Sensor Fusion Based on Statistical Inference**

PI   **Ramanarayanan Viswanathan**

In the six month period between June 1996 and November 1996 we have looked into two problems related to data fusion from multiple sensors. The first deals with the distributed constant false alarm rate radar target detection and the other examines a rank based test for M-ary detection problem.

We obtained more results on the performance of the normalized test statistic, where the data from the test cells of each sensor are weighted and then added to form the test statistic[1,2]. For a two sensor network, the performance of this test is compared with that of the standard OR rule. In both homogeneous background and interfering target situations, the probability of detection of normalized test statistic is only slightly larger than that of the OR rule. The drawback of both these tests is the large increase in false alarm rate during a clutter transition in the middle of the reference window[2]. Also, during this period, a comprehensive review of CFAR tests which are based on order statistics has been written[3]. We are currently looking into alternate schemes that use more than one order statistics for clutter power estimation.

We examined a rank order based test for a general M-ary communication problem, which is stated as follows: Given M groups of L samples each, the problem is to identify which unique group of L samples have come from the signal hypothesis. The optimal likelihood ratio test that minimizes the probability of incorrect classification can be constructed if the joint distribution of these ML samples is completely known. However, in many cases, the distribution is either unknown or only known partially. Therefore, suboptimal tests, such as tests based on rank orders, can be considered. By considering the observations as a matrix of M rows with L columns, a rank matrix is created by rank ordering these observations and then replacing the samples with their corresponding ranks. Then a *Rank Sum Test* declares the row with the maximum rank sum as the row corresponding to the signal hypothesis. Since ranking ML samples might take considerable amount of time, a *Reduced Rank Sum Test* (RRST) rank orders the samples in each column separately into values of 1 through M, and then picks the row with the maximum rank sum. A variation of the RRST is to create a value matrix where the (i,j) element of the value matrix is either equal to the (i,j) element of the rank matrix, if the rank exceeds a threshold t, or is equal to zero. The *Modified Rank Test* (MRT) then picks the row with the maximum sum of values. If $t=M$, the MRT retains only the maximum rank of M in each column and assigns zero values to the others. In other words, independently for each column, the row with the largest rank is decided as the signal row. Therefore, for $t=M$, MRT can be thought of as a majority logic combining of the decisions made in each column. For other values of t, MRT can be thought of as combining decisions, when decisions are presented with confidence weights. We examined small sample as well as large sample efficiency of MRT for detecting a signal in various noise distributions[4].

Publications

1. C.H. Gowda, M.K. Uner, P.K. Varshney and R. Viswanathan, "Distributed CFAR target detection," Proceedings of workshop on Foundations of Information/Decision Fusion, Washington D.C., Aug. 1996, pp. 79-84. Also to appear in Journal of Franklin Institute, 1997.

2. C.H. Gowda and R. Viswanathan, "Performance of Distributed CFAR Tests in Nonhomogeneous Background," accepted for presentation at National Radar Conference, 1997.

3. R. Viswanathan, "Order Statistics Application to CFAR Radar Target Detection," in *Handbook of Statistics, Vol. 16- Order Statistics and Their Applications*, N. Balakrishnan and C.R. Rao Eds., North-Holland Publishers.

4. V. Annampedu and R. Viswanathan, "A Rank Based Test for M-ary Detection," submitted to Conference on Information Sciences and Systems, Johns Hopkins University, 1997.